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## Solar disinfection of water (A case study from Kenya)

*Stephen Burgess and Collins Onyonge, Kenya*

THE WATER SUPPLY and Sanitation Project being implemented by the Christian Community Services works with rural self help groups to improve their access to clean, safe, domestic water. Operating in the North Rift area of Kenya the groups are building household rainwater catchment systems, protecting shallow hand dug wells and using rope and washer pumps. This provides for water supply, but one important issue is how to ensure the water is safe. As the project objective is to improve the health status of the community, environmental hygiene and sanitation training plus awareness raising has been undertaken in order to reduce the risk of waterborne disease transmission, (Faecal – oral cycle).

Rainwater, collected in the roof catchment tanks, is a good source of safe water provided precautions are taken to maintain cleanliness of the RWCS. Common source of water in the area are the rivers, unprotected shallow wells and springs which are contaminated by pathogens that cause disease. A high incidence of diarrhoea, and even typhoid, is reported suggesting that a contamination problem exists. Currently the community members treat their water by settlement or storage. Disinfection by boiling is practiced but due to time pressure and the effort involved in collecting firewood and boiling water the practice is often neglected.

An alternative method of water disinfection, SODIS, Solar Disinfection of water has been promoted with some of the groups to provide safe, household drinking water. This paper reports the experiences from these groups.

The technique of SODIS has been researched and reported widely (Acra et al., 1984; Wegelin et al., 1994; Lawand et al., 1988; Sommer et al., 1997). The following technical details are taken from a series of Technical notes; (EAWAG, 2000). This research shows that the UV-A component of sunlight, plus the synergy effect of infrared radiation (heat), is effective in destroying pathogenic bacteria and viruses: *E. Coli*, *Vibrio Cholerae*, *Str. Faecalis*, *S. Paratyphii*, *S. typhii*; bacteriophage F2, rotavirus, Encephalomyocarditis virus; yeasts and moulds. The inactivation of spore and cyst forming organisms, such as protozoa and helminth, by SODIS has not been systematically assessed (EAWAG 2002).

### What is SODIS?

- A treatment method to eliminate the pathogenic microorganisms which cause water-borne diseases.
- Ideal to disinfect small quantities of water used for consumption

A water treatment process depending on solar energy only

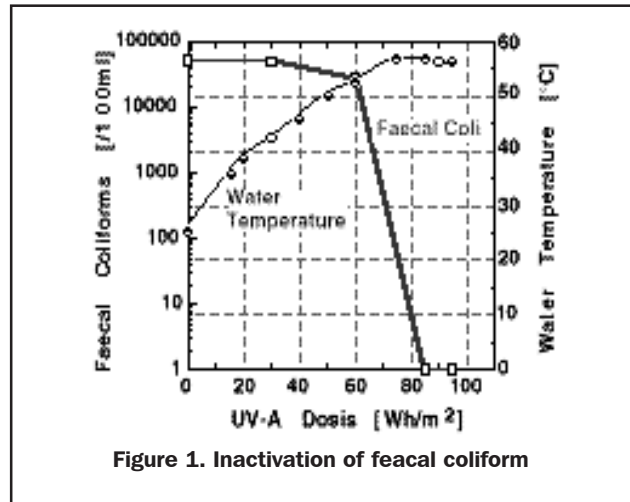


Figure 1. Inactivation of faecal coliform

- An alternative water treatment option for use mainly at household level
- An old, but so far hardly applied water purification method

### How does it work?

The best use of solar energy is the combined application of two treatment processes. First, the UV-A radiation from the sun to kill microorganisms; second, the Infra-red component heating the water to enhance the kill-rate of microorganisms. Combined, the double energy, or **synergy**, is sufficient to purify the water (See Figure1).

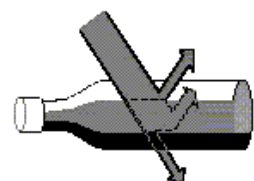
### Practical technique

The treatment basically consists in filling transparent plastic (PET plastic), or glass bottles with water and exposing them to full sunlight for at least five hours. To absorb more heat and raise the water temperature the bottle is painted black on one side and placed on a black surface, in the sun, with the clear side facing the sun. The process is more effective if the water is aerated by shaking to introduce oxygen while filling the bottles.

#### Exposure time:

5 hours under bright or up to 50% cloudy sky  
Or 2 consecutive days under 100% cloudy sky

SUNLIGHT



### SODIS use with community self help groups

Using the power of sunlight is not a new concept to rural Kenyan women; commonly outside the house is a raised wooden platform on which pots, plates and utensils are placed to dry after washing. The women say that the sunlight helps to kill any germs. Building on this, the concepts and practice of SODIS for disinfecting household drinking water were taught, using information as above. The equipment needed to “try” using SODIS was obtained. A SODIS kit consists of the following:

- 3 to 6 PET plastic bottles, 1 to 2 litre size, can be bought second hand in the local market, or are available after drinking the orange cordial. It was important to find bottles without scratches and with tight fitting lids.
- Black paint, as used on school blackboards, was purchased and the women painted their own bottles half-black.
- A black surface on which to place the bottles was made by painting a small piece of corrugated GCI roof sheet.
- The bottles are placed in the sun, on the dish rack, on a raised platform or on an existing roof surface (i.e. away from animals).

The cost of a SODIS kit with 3 bottles and GCI sheet painted was about \$US 1.50, figure 2.



Figure 2. Monica with her SODIS kit

### The technique and use of SODIS was not difficult for the women

The bottles were cleaned, cap checked for tightness and filled completely with the raw water. Their sources of water were unprotected springs (Figure 3), protected shallow wells and rainwater tanks. Early in the morning, 7am or 8am, the bottles were put on the black surface in the sun. On bright sunny days and on partly cloudy days the bottles were left all day (8 hrs) and fully cloudy days for two consecutive days.

After SODIS the water was either left outside or brought into the house to cool overnight. The water in the SODIS



Figure 3. Source of water for Monica, unprotected spring

bottle was decanted into another storage bottle or drank straight from the SODIS bottle.

The main concern of the users of SODIS was—“Does it work? Does it kill the germs?” In order to answer this question a series of Bacteriological tests for faecal coliform were carried out using a DELAGUA membrane filter/incubation kit in August 2000 to April 2002. When shown the results of these tests on their own water the community members were convinced. Table 1 below compares faecal coliform counts for raw water and SODIS treated water; Number of faecal coliform per 100ml of water.

Faecal coliform is an ideal indicator of pathogenic micro-organisms which are human faecal in origin. WHO recommends this as the indicator organism when testing facilities are limited. (WHO, 1993)

### The results show

1. That SODIS works- the faecal coliforms were killed. More importantly, as the SODIS was carried out by the group members themselves, they were able to successfully disinfect their water using SODIS.

One lady, Monica, SODISed the water for two consecutive days. Perhaps a good precaution when the turbidity of the water is >20 NTU, although tests undertaken by staff, 8hrs SODIS, showed that faecal coliform were killed. One lady, Helen, reduced the turbidity of her raw spring water using alum before SODIS.

The results of the tests were not always 100% destruction of faecal coliform by SODIS. Where contamination was still evident, the group member explained how she was using SODIS and reasons sought. After “re-teaching” the SODIS was successfully done. Also seen is the danger of recontamination of the clean SODIS water when the water is put in another storage container. Discussion with the group members and awareness raising would reduce the incidence of recontamination.

2. That a protected well with a hand pump has “good” quality water compared to unprotected sources.
3. Rainwater is a clean, safe source. No faecal coliforms seen.

<b>Table 1: Bacteriological water tests</b>	<b>Raw Water</b>	<b>SODIS water</b>	<b>Comment</b>
<b>Water Source and Type</b>	<b>FC per 100 ml</b>		<b>SODIS use</b>
<b>Jikoni Group</b>			
Protected well, rope to draw water, Sirma	4 to 18	0 to 1	8 hours hot sun
Protected well, hand pump, Maiyo	0 to 2	-	Sodis not tested
Rainwater tank, Dorcas	0	0	8 hours hot sun
Unprotected spring, Helen (<5 NTU)	8 to 15	0	8 hours hot sun
SODIS water storage bottle, Helen	0	-	No recontamination
Unprotected spring, Monica (20 NTU)	244	0	16 hours hot sun
Mondui Spring, unprotected (20 NTU)	175 - 500	0	8 hours hot sun
<b>Gatina Group</b>			
Protected well, handpump, Tabitha	2 to 18	0	8 hours hot sun
SODIS water storage bottle, Tabitha	1 to 4	-	Recontamination
Protected well, handpump, Nyambura	12	0	5 hours hot sun*
Protected well, handpump, Charles	0	-	Sodis not tested
Various rainwater tanks	0	0	8 hours hot sun*
Note: * Indicates that the SODIS was undertaken by staff to verify the technique The turbidity of the water was < 5 NTU unless indicated			

Further tests undertaken by staff showed that the SODIS water temperature in the bottles reached a maximum of 45 degrees centigrade for about 1 hour in the middle of the day (Fig 4), this is less than the 50 degrees centigrade in Fig.1. The community members were advised to SODIS the water for the whole day, 8 hrs, rather than 5 hours minimum.

### Acceptability of SODIS

The acceptability of SODIS to group members was assessed by two methods: Individual or group interviews and group matrix ranking comparing alternative methods of getting safe drinking water.

#### Positive comments given by women group members

- I use SODIS now every day and it provides for all the household drinking water needs.
- SODIS is easy to use. I just put the bottles out in the morning and “forget” about them. In the evening when I have finished my other work I just bring them in.
- Before I used to boil water which was time consuming and the smoke from the fire gave the water a bad taste. SODIS water tastes good.
- I do not need to go and collect so much firewood now. SODIS saves time that I then use to care for my family's needs.
- SODIS is cheap and we can get the bottles ourselves.
- SODIS does make water safe, we no longer get headaches, (associated with typhoid), and diarrhoea.

#### Challenges and questions raised by group members

- Does SODIS really kill all the harmful microorganisms?
- What about amoebae (cysts) and worms?

- At cloudy times, during the rainy season, will SODIS still be effective?
- After how long should SODIS water be drunk? (a question relating to re-growth of micro-organisms)
- Care needs to be taken to keep the SODIS bottles clean and replace them if they become scratched or broken.
- Can we use other methods for the black surface, as GCI sheet is expensive? What about black, plastic sheet?
- Culturally, black is associated with magic, so half-black bottles are a problem. Can clear bottles be used?

#### Comments on further tests

Tests undertaken showed that there is no significant difference between the maximum daily temperature of water for 5 different surfaces, Figures 4 and 5. However it can be seen that the highest water temperatures are reached with shiny GCI sheet and half- black bottles, Fig 4. This is confirmed

